NOTE ON A POSSIBLE FACTOR IN CHANGES OF GEOLOGICAL CLIMATE

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In a recent discussion of the factors that control variations of world climatic conditions, Professor Humphreys has criticized the various astronomical hypotheses that attempt to explain the ice ages and other features in geological climate.[1] Several factors, formerly given weight, are held responsible only for effects of the second order at most. Among the insufficient interpretations he would place Croll's theories which involve the changing elements of the earth's orbit, and the various hypotheses connecting sun spots (and other intrinsic changes in solar radiation) with terrestrial insolation and the climates of the geologic past.

The primary factors of climatic control clearly appear to be of terrestrial origin—land elevation (and its concomitant factors of oceanic and atmospheric distribution and circulation), combined with vulcanism. Cosmic factors are evidently not of primary importance. The observed connection of climatic phenomena with land elevation can by no means be attributed to chance. A cosmic non-terrestrial origin for the principal factors of climatic control would therefore leave unexplained such significant coincidences as mountain forming and glaciation, since one could hardly propose seriously that cosmic factors are the cause of both topographic and climatic change.

One astronomical possibility that I believe has not been urged heretofore appears, however, as a result of recent observation, to deserve attention as a potential secondary factor in recorded geological climates, and possibly even as a primary agent at some prehistoric time.

[1] W. J. Humphreys, "Factors of Climatic Control," *Jour. Frank. Inst.* *CLXXXVIII* (1919), 775; *CLXXXVIII* (1920), 63.

1. Barnard, Wolf, and others have shown the very common existence of extensive, diffuse, irregular, luminous and non-luminous nebulosities in the sky, and I have previously called attention to the apparent affiliation of Barnard's dark nebulae with our local cloud of stars; Hubble's unpublished observations appear to substantiate this affiliation of the dark markings and demonstrate their relative proximity to the solar system.

2. The great Orion nebula is one of the luminous or partially luminous members of this group of nebulosities, and spectroscopic observations by Fabry, Frost, and Campbell and their associates have shown that its various parts are moving relative to each other with velocities of several kilometers a second.

3. In and near the Orion nebula more than seventy faint stars that vary in light have been found at the Harvard, Heidelberg, and Yerkes observatories, and elsewhere; Lampland has also found similar variables in the comparable nebula Messier 8. My work on the variables in Orion has shown: (*a*) no certain periodicity in the variation, (*b*) light curves not comparable with known types, (*c*) a variety of color types among the variables, and (*d*) no evidence of great range or of extinction (as would be expected from occultations).

4. Van Maanen's discussion of the proper motions supports the inference, based on the distribution of the variables, that they are really associated with the Orion nebula and with the cluster of brighter stars in that vicinity. The distance of this group of stars, according to Russell and Kapteyn, is six hundred light-years. The diameter of the region throughout which these peculiar variables are known is fifty thousand times the diameter of Neptune's orbit, and the total nebulous region in Orion is many times larger. (From the present direction and amount of their motions, we compute that a few million years ago our sun was in the vicinity of the Orion nebula; at its present speed the sun would require nearly a million years to pass through that particular nebulous region).

5. From the known distance of the variables in Orion, and my measures of their apparent magnitudes, it is easily computed that in luminosity they are dwarfs. This supports the conclusion from the study of their light curves that the Orion variables differ

from all other types of variables, which almost without exception are giants in luminosity.

6. In view of (*a*) the irregularities of the light variations, (*b*) the apparent immersion of the variables in nebulosity, and (*c*) the spectroscopic evidence for the irregular churning about of this nebulous matter, it seems reasonable to believe that the variations in brightness result from collision or friction with the irregular nebulosity in which the variables are involved. The encounter of star with nebula is at present the best, though perhaps not an entirely satisfactory, explanation of the cause of galactic novae; and it is the only hypothesis that has been suggested to account for temporary stars in the rapidly moving spiral nebulae.

7. Long-exposure spectrograms of the Orion nebula, using the 100-inch reflector and a rapid focal-plane spectrograph, have recently shown in the bright-line spectrum the presence of hydrogen, nebulium, helium, carbon, and nitrogen; they also show a faint continuous spectrum in all parts of the nebula.

8. The bearing of the foregoing observations on the question of geological climates becomes obvious when we note the following points: (*a*) The condition that causes variation of a star in the Orion nebula must also gravely affect the atmosphere surrounding any attendant planet. (*b*) The sun is moving with a velocity of 20 kilometers a second through a region of space, large sections of which are known to be occupied by diffuse nebulosity (most of it probably much less dense than that in Orion). (*c*) The observed variation of the friction variables in Orion is generally from 20 to 80 per cent of the total light, and sometimes appears rapidly oscillatory, sometimes secularly progressive, sometimes a discontinuous brightening or dimming. (*d*) A change of 20 per cent in the solar radiation, if maintained for a considerable period of years, would sufficiently alter terrestrial temperature to bring on or remove an ice sheet; an 80 per cent change, unless counteracted by concurrent changes in the terrestrial atmosphere, would completely desiccate or congeal the surface of the earth.

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